Chapter 20

Machinery

THE machinery industries make as primary products not only machinery itself, but also parts for use in the manufacture of machinery.[1] Industries producing transportation equipment are classified in a separate group. In terms of value added, the machinery industries constituted the most important of all manufacturing groups in 1937, having risen from fourth place in the years following 1899.

TRENDS IN THE PHYSICAL OUTPUT OF THE MACHINERY INDUSTRIES

The task of measuring the physical output of machinery is complicated by two serious difficulties. In the first place, few of the machinery industries are covered by adequate quantity data on output; and in the second place, the available statistics are ambiguous because the products are not divided into homogeneous subclasses.[2] Inadequacy of data and of sub-classification are almost inevitable when the variety of items produced is as wide as it is in the case of machinery, and no classification, no matter how detailed, could be expected to resolve the problem conclusively. The enormous variety of machines [3] illustrates rather pointedly the extent to which

[1] In order to keep the composition of the machinery group constant, we have treated carbon paper and steel barrels as machinery industries. See Appendix C.

[2] For examples of inadequate classification, see Appendix A.

[3] The Bureau of the Census cites, in 1937, more than 20 major classes of machine tools (including the ubiquitous "all other" class) —bending machines, boring machines, boring mills, broaching machines, drilling machines, etc. The classes are broken down further into more than 90 subclasses. Thus,

our industrial processes are both specialized and mechanized. The continuing improvements in our productive equipment, tools and machines, reflect the drive toward faster, better, cheaper production—a basic factor in our economic progress.[4] In other words, some of the very factors that have made this a machine era also make it impossible for us to measure in a straightforward manner the degree to which the physical

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under the caption "drilling machines" are differentiated horizontal, vertical and radial drilling machines, and the vertical machines are subclassified into multiple-spindle (other than sensitive), standard, sensitive (including bench-type) single spindle, sensitive (including bench-type) multiple spindle, etc.

[4] It is scarcely necessary to offer a long list of improvements in machinery. Even simple tools and dies have had their usefulness extended 3 to 20 times by chromium plating. See David Weintraub, *Effects of Technological Developments upon Capital Formation* (Report No. G-4, National Research Project, March 1939; reprint from *American Economic Review*), p. 8. Sizes of equipment have changed. Industrial-type locomotives increased in average size from 7.4 tons in 1924–27 to 11.4 in 1932–36 (*ibid.*, p. 3). The dipper capacity of power shovels sold to mining industries by a sample of representative companies rose from 1.7 cubic yards in 1920–23, to 3.3 cubic yards in 1932–36 (*ibid.*, p. 3). Driers used in phosphate-rock mining increased in length from 12–25 feet in 1895 to 30–60 feet in 1936; in diameter, from 30–36 inches in 1895 to 42–90 inches in 1936; in capacity from 6–10 long tons of dried rock per drier-hour in 1895 to 20–110 tons in 1936. See A. P. Haskell, Jr., and O. E. Kiessling, *Technology, Employment, and Output per Man in Phosphate-Rock Mining, 1880–1937* (Report No. E-7, National Research Project, Nov. 1938), p. 36. Further illustrations of increases in the size of individual equipment units will be found in Harry Jerome's *Mechanization in Industry* (National Bureau of Economic Research, 1934), p. 245. Machines have been made safer and therefore less expensive to operate: in 1913, the frequency of accident per million hours' exposure, caused by machinery in a sample of six iron and steel plants, was 7.3. The corresponding figure for 1931 was 1.7; "Accident Experience in the Iron and Steel Industry to the End of 1931," *Monthly Labor Review* (March 1933), p. 533. Machines have become more economical of fuel, as we have noted elsewhere in this volume. Other improvements have been effected; witness the adoption of caterpillar traction in shovels used in strip mining, and the supplanting of steam by electricity in this and in many types of equipment. Because of these changes, and also because of increases in size and power, the average tonnage handled per stripping shovel per day rose from 164 in 1915 to 276 in 1928; "Employment in Relation to Mechanization in the Bituminous Coal Industry," *Monthly Labor Review* (February 1933), p. 264.

Shifts in the relative importance of different machines performing the same general functions are relevant also. For example, there is the automatic bottle machine, making half-ounce prescription ovals. The Owens A. V. (15 arms) single, with conveyor, produced 20.3 bottles per hour in 1918, 24.8 in 1920.

volume of output of machines has risen, and the size of the existing stock of mechanical instruments.

All but one of the indexes for the few machinery industries for which there are adequate quantity statistics (Table 59 and Chart 22) begin with 1921 or an even later year. Because of the deficiencies in the data which we have already noted, no index for the group as a whole could be computed by us. (An index computed by W. H. Shaw is described below.)

Agricultural Implements. The output of this industry fell 10 percent from 1921 to 1925. From 1925 to 1929 there was a rapid rise of 64 percent, but from 1929 to 1937 there was a drop of 2 percent, the net effect of an extremely severe decline from 1929 to 1931, and a sharp rise from 1931 to 1937.[5] Most of the products of the industry evidence a trend toward tractor-drawn, and away from horse-drawn, machinery. Between 1929 and 1937 horse-drawn plows fell from 504 thousand to 316 thousand, while tractor plows rose from 123 thousand to 149 thousand.

Phonograph output is covered by data for the period 1899–1929. The absence of more recent statistics is not to be ascribed simply to a deficiency in Census coverage, for the industry lost its independent status in 1931, when it was

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The Owens A. V. (15 arms) double, with conveyor, produced 43.4 bottles per hour in 1925. In the same year the Owens A. N. (ten arms) double, with conveyor, produced 33.0 bottles per hour; while the Owens C. A. (ten arms) double triplex, with conveyor, produced 79.5 bottles per hour; U.S. Bureau of Labor Statistics, "Productivity of Labor in the Glass Industry," *Bulletin 441*, p. 60. Shifts in the relative numbers of such machines produced result in broad changes in the "quality" of the general class of automatic bottle machines.

[5] For 1933 the coverage of our data is only 27 percent—not extensive enough to justify the construction of an index. These data suggest, however, that in the year 1933 output was at an even lower point than it had been in 1931.

The indexes for 1935 and 1937 are unadjusted for changes in the coverage of the sample from 1931 to 1935 and 1937 (see Appendix B). If such changes occurred, they were probably upward, because repair and similar work—not covered by the available quantity data—must have declined in relative importance as revival proceeded. If this assumption is correct, the index we present for 1937 is too high, perhaps by as much as 25 percent; in other words, the 1937 output of the industry may have been 20 or 25 percent below that of 1929, and not approximately equal to it.

TABLE 59

MACHINERY[a]
Physical Output: Indexes and Percentage Changes[b]

YEAR	Agricultural Implements	Phonographs	Radios	Refrigerators, Mechanical	Scales and Balances	Sewing Machines	Typewriters	Washing and Ironing Machines
				INDEX OF PHYSICAL OUTPUT (1929:100)				
1899	..	8.3	..	..	..	..	..	..
1904	..	..	..	..	..	..	..	..
1909	..	29	..	..	..	..	..	..
1914	..	38	..	..	..	..	..	..
1919	..	182	..	..	..	..	51	..
1921	68	80	3.8	0.6	..	..	73	..
1923	64	105	47	2.0	..	..	78	..
1925	61	80	40	8.4	..	..	91	..
1927	73	114	100	44	83	101	100	73
1929	100	100	74	100	100	100	100	100
1931	30	..	75	118	60	49	54	79
1933	..	..	106	130	35	26	43	92
1935	50	..	144	212	62	57	83	132
1937	98	..		317	87	100	109	146
PERIOD				NET PERCENTAGE CHANGE IN PHYSICAL OUTPUT				
1899–1937	..	..			..		..	
1899–1909	..	+253			..		..	
1909–1919	..	+520	..		..		..	
1919–1929	..	−45	..		..		..	..
1929–1937	−2	..	+44	+217	−13	0	+9	+46

[a] Industries for which there are no adequate quantity data for any period listed above are: foundry and machine-shop products, not elsewhere classified; business machines; carbon paper; electrical machinery; engines and tractors; windmills; steel barrels; machine tools; machine-tool accessories, not elsewhere classified; pumps; textile machinery; gas machines and meters; and refrigerators, non-mechanical.

[b] The indexes have been constructed from basic data in the described briefly in Chapter 2 and in detail in Appendix A. Appendix B presents these data, together with the indexes derived from them. The indexes have been adjusted to take account of changes in the coverage of the respective samples, except when such adjustment was impossible.

The percentage changes are not always entirely consistent with the indexes given above because the changes were computed from the indexes in Appendix B, which are carried to

classed as a branch of the radio industry; the phonograph was
now regarded largely as an adjunct of the radio-phonograph
combination. The output of the phonograph industry rose
rapidly from 1899 to 1909 and from 1909 to 1919, gaining
250 and 520 percent in these two periods, respectively. After
reaching a peak in 1919 it declined sharply to 1923, then un-
derwent some fluctuations until 1929. From 1919 to 1929 the
net loss was 45 percent.

Between 1899 and 1929 the output of the phonograph in-
dustry increased by 1100 percent. The output of the chief
product, phonograph machines, rose from 151 thousand to
755 thousand between these two years. Phonograph records
and blanks increased in output from 2.8 million in 1899 to
105 million in 1929.

Radios. This industry was not shown separately in the
Census until 1931, but information is available on radio pro-
duction from 1923 on.[6] In that year 190 thousand receiving
sets were built (excluding crystal and short-wave sets). By
1929 output had reached almost 5 million sets, a rise of 2,500
percent. From 1929 to 1937 the net increase was 44 percent.
The retardation in rate of growth is rather surprising when
we consider the brief span of the period covered. The com-
position of the industry's output changed as the result of an
extremely rapid rise in automobile sets between 1931 and
1937 (from 93 thousand to two million sets), and a decline in
radio-phonograph combinations between 1929 and 1937.

Mechanical Refrigerators rose spectacularly from 5,000
units in 1921 to 900,000 in 1929 and to 2,800,000 in 1937.[7]
The percentage increase in the first period was huge, of course.
In the last period the rise exceeded 200 percent. These great
increases, as might have been expected, caused a drastic de-
cline in the output of nonmechanical refrigerators. Manufac-

[6] These data are not derived from the Census, and are unadjusted for change
in coverage. See Appendix B.

[7] These data, also, are derived from sources other than the Census, and are
unadjusted for change in coverage.

Chart 22

MACHINERY

Indexes of Physical Output

Agricultural implements

Refrigerators, mechanical

Phonographs

Percentage
change

+400
+350
+300
+250
+200
+150
+100

+ 50

0

Radios

− 50

Ratio scale

1899   1909   1919   1929   1937   1899   1909   1919   1929   1937
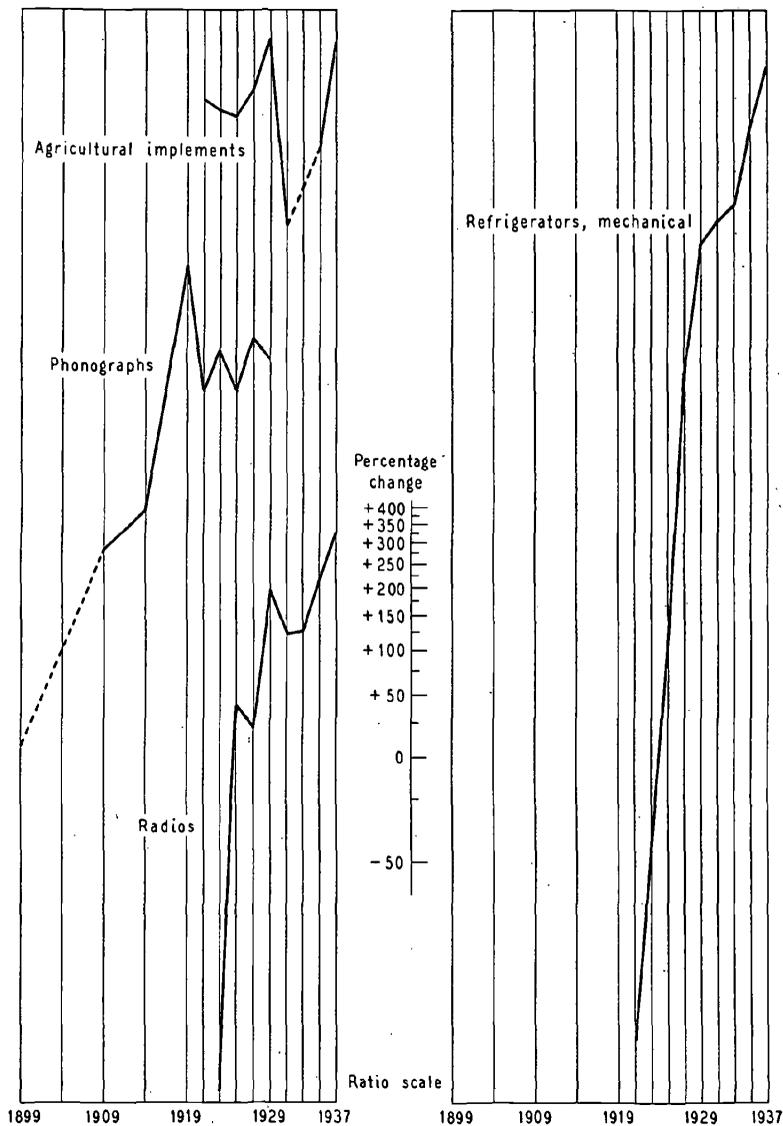
Chart 22 (concl.)

MACHINERY

Indexes of Physical Output
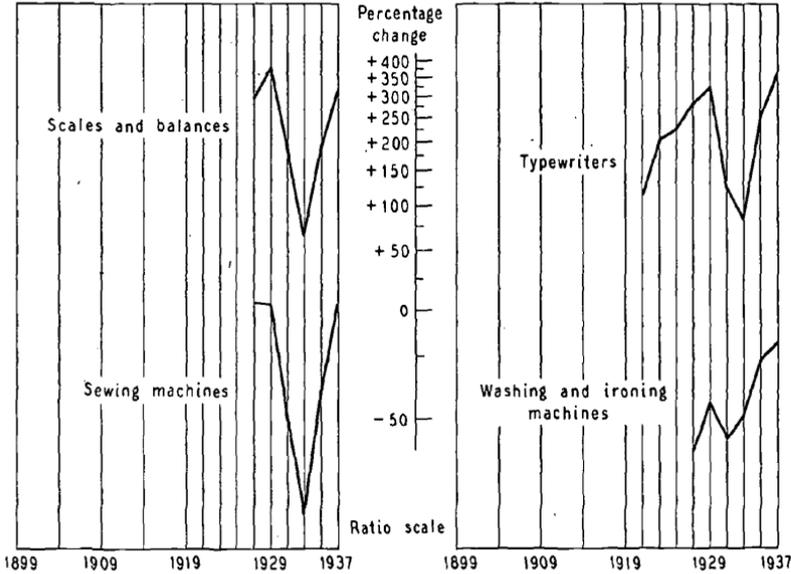
turers' sales of ice-boxes reached their Census year peak in 1925. In 1937 ice-box sales totaled less than a third of the 1929 volume and only about a tenth of 1925 sales.[8] The decline in the output of manufactured ice from 1929 to 1937 has already been noted (Chapter 6).

Sewing Machines declined from 1927 to 1929, but to a very minor extent, and rose in similarly small degree from 1929 to 1937. Machines of the industrial type gained at the expense of household machines in the entire decade 1927–37; this development was obviously a reflection of the changes noted above in the discussion of the textile industries (Chapter 9).

Typewriters. The output of the typewriter industry moved rapidly upward from 1921 to 1929.[9] The gain from 1923 (a

[8] *Refrigeration and Air Conditioning Market Data* (Business News Publishing Co., Detroit, 1935), p. 64. The data do not cover all plants.
[9] The index for 1921–29 is unadjusted for changes in coverage.

peak year in general business activity and therefore more comparable with 1929) to 1929 was 36 percent, and from the latter year to 1937 output increased again by 9 percent. The output of portable typewriters rose in these years while that of standard typewriters fell.

Other Machinery Industries. Adequate quantity data are not available for the most important industries in the group —foundry and machine-shop products, electrical machinery, and engines and tractors. Since even a rough notion of the changes in the output of these industries is preferable to none at all, we present in Table 60 the data on value added expressed as percentage changes from 1899 to 1937, and as percentage changes in relation to corresponding changes in the total value added by all manufacturing industries combined.

TABLE 60

MACHINERY

Changes in Value Added, 1899–1937[a]

Industry	Percentage Change in Value Added	Percentage Change in the Ratio of Value Added to Total Value Added by All Manufacturing Industries
Foundry and machine-shop products, n.e.c.[b]	+548	+13
Agricultural implements	+153	−56
Business machines	+1,956	+259
Typewriters and carbon paper	+633	+28
Electrical machinery	+2,548	+362
Pumps	+3,263	+487
Scales and balances	+227	−43
Sewing machines	+144	−57
Washing and ironing machines	+1,694	+213
TOTAL	+752	+49

[a] Basic data are given in Appendix C.
[b] N.e.c. denotes not elsewhere classified. This classification includes the following industries shown separately in Censuses after 1899: cast-iron pipe, engines and tractors, windmills, steel barrels, textile machinery, and machine tools.

Foundry and machine-shop products, the basic industry, increased its value added by over 500 percent. Electrical machinery exceeded this rise, augmenting its value added by 2,500 percent. Business machines increased in this respect almost 2,000 percent; typewriters and carbon paper, over 600 percent; pumps, 3,200 percent; and washing and ironing machines, 1,700 percent. Agricultural implements, scales and balances, and sewing machines made slighter gains, ranging from 144 to 227 percent. The entire group increased its value added by 750 percent. The last three industries fell below total manufacturing in rate of increase in value added, and the other six surpassed the total.

Even the value data for the machinery group are inadequately classified by industries. In the 1899 Census the foundry and machine-shop products industry included engines, machine tools and textile machinery. These are shown separately for the period 1919–37:

	Percentage Change in Value Added, 1919–37	Percentage Change in the Ratio of Value Added to Total Value Added by All Manufacturing Industries, 1919–37
Engines, tractors, and windmills	−33	−40
Steel barrels	+83	+64
Machine tools	+32	+18
Textile machinery	−6	−15
Foundry and machine-shop products (excluding above)	+8	−4

Steel barrels and machine tools increased their value added more rapidly between 1919 and 1937 than did all manufacturing industries combined. Foundry and machine-shop products, excluding the four industries listed separately, rose in value added by 8 percent, but fell behind total manufacturing by 4 percent. Engines and textile machinery declined both absolutely and in relation to total manufacturing.

The great rise in the output of electrical machinery re-

flects, among other things, the increased utilization of power equipment in business establishments. This trend is revealed by the figures cited below, which relate to the aggregate horsepower of power equipment reported by manufacturing plants alone:

Year	Prime Movers (nonelectrical)	Electric Motors Driven by Energy Generated in Reporting Establishment	Driven by Purchased Energy
		(Unit: Million Horsepower)	
1899	9.8	0.3	0.2
1909	16.8	3.1	1.7
1919	20.0	7.0	9.3
1929	20.2	12.4	22.8

All three types of equipment rose between 1899 and 1929, the latest year for which the data are available. But the rate of increase in the horsepower of electrical equipment far exceeded that of such nonelectrical prime movers as steam engines, internal-combustion engines, and water-wheels and turbines. The rate of output of new electrical equipment is indicated more clearly by the net increments. During the decade between 1899 and 1909 there was a net increase of 4.3 million horsepower for all electric motors used in manufacturing. In the second decade, 1909–19, the increase was 11.5 million; and in the third, 18.9 million, a rise more than four times as great as that occurring in the first decade.

These figures are much more significant than their effect on a single industry, electrical machinery, would seem to show. The most important inference to be drawn from them concerns the application of power in manufacturing. Clearly, more mechanical power was utilized in 1929 than at the opening of the century. The three columns of figures are not additive,[10] but there is hardly any question that the

[10] See W. L. Thorpe, "Horsepower Statistics for Manufactures," *Journal of the American Statistical Association* (Dec. 1929).

capacity of the power equipment used in factories increased much more rapidly than the number of workers, and—though this is less certain—somewhat more rapidly than the total quantity of output. The bearing of this development upon trends in productivity, and thereby in production, needs no emphasis.

Scarcely less significant is the fact that factories have transferred some of their functions to nonmanufacturing industries. A growing fraction of the power used in manufacturing is being purchased from the electric light and power industry, and a declining fraction is being made on the premises. During the decade 1919–29 there was virtually no increase in the horsepower of prime movers owned by factories, whereas motors driven by purchased current more than doubled in horsepower capacity. The increasingly fine division of labor also has been conducive to increases in productivity in manufacturing, since central power production is more efficient than local production. At the same time, it is difficult to interpret the usual measures of productivity, since the increases in employment in central power stations are not reflected in the employment figures for manufacturing plants.

Still another bit of general information may be extracted from the statistics on horsepower. The increase in the horsepower of electric motors driven by energy produced in the reporting establishment has proceeded at a greater rate than the increase in the horsepower of the prime mover. This divergence suggests that increasingly widespread use has been made of a highly flexible method of transmitting power from the prime mover to the point of application. A development of this sort must have had a far-reaching effect not only upon plant layout, but also upon manufacturing production and efficiency.

The Group Total. The machinery group as a whole increased its value added almost 50 percent more than did all

manufacturing industries combined. This finding indicates that there must have been a substantial relative rise in the group's physical output, though the exact amount cannot be determined. A rough check on this conclusion is provided by estimates of machinery output, made by W. H. Shaw and presented below. Mr. Shaw arrived at these estimates by deflating the value of production of machinery by whatever appropriate price series could be secured.[11] The price data are necessarily fragmentary, and the indexes of physical output thus obtained must therefore be regarded only as approximate measures. They indicate that machinery output rose,

	Indexes (1929:100)	
	Machinery Production	Machinery Production in Relation to Total Manufacturing Production
1899	22	79
1904	28	81
1909	37	85
1914	40	78
1919	67	109
1921	43	80
1923	71	93
1925	73	89
1927	77	89
1929	100	100
1931	54	75
1933	29	46
1935	65	79
1937	107	103

between 1899 and 1937, about 30 percent more rapidly than total manufacturing output. The estimates, then, tend to confirm the trend indicated by the data on value added. Of particular interest is the movement from 1929 to 1937 as shown by the indexes. There appears to have been an appreciable gain in machinery output between these two years, exceeding the corresponding rise in total manufacturing.

[11] These figures will be presented and discussed in a report by Mr. Shaw to be published by the National Bureau of Economic Research.

To persons living in an age characterized by increasing
mechanization on all fronts, the relative gain of 30 or even
50 percent indicated by the data presented here may appear
slight rather than otherwise. It must be remembered, how-
ever, that increasing mechanization has been a causal factor
in the augmented output of other goods; and further, that
mechanization results from improvements in the quality and
performance of machines, and not merely from increases in
their number.

CHANGES IN THE INDUSTRIAL PATTERN OF
MACHINERY OUTPUT

The data on the physical output of the machinery group are
so inadequate that we must turn to data on value added
(Table 61) for information on changes in composition.

As the table shows, the largest industry in the group,
foundry and machine-shop products, made only a slight
change in its contribution to the value added by the entire
group. This contribution includes the value added by a
number of offspring industries, and it is obvious that a de-
clining trend would emerge if we were to treat the parent
industry separately. Agricultural implements lost consider-
able ground. In 1899 this industry contributed 12.6 percent
of the group's value added, but in 1929 less than 4 percent. A
relatively minor decline characterized the movement of value
added by the sewing-machine industry.

The contribution of electrical machinery increased sub-
stantially, from 9.5 percent to over 25 percent of the group
total. An appreciable rise occurred also in the contribution
of pumps and business machines. The value added by phono-
graphs rose until 1919, then declined as a fraction of the
total. The relative increase in mechanical refrigerators is
noteworthy even in the last period, the only one for which
we have data on this industry.

TABLE 61

MACHINERY

Relative Contributions of Component Industries to the Value Added by the Entire Group[a]

Industry	Percentage Distribution, Comparable Pairs of Years							
	1899	1909	1909	1919	1919	1929	1929	1937
Foundry and machine shop products, n.e.c.[b]	69.8	64.5	61.8	64.0	46.0	41.2	39.1	38.6
Business machines	1.1	2.5	2.7	2.5	2.5	2.3	2.2	2.6
Typewriters	}1.2	1.9	2.1	1.2	1.3	1.5	{1.2	0.8
Carbon paper							0.2	0.2
Electrical machinery, incl. radios	9.5	13.8	14.9	19.6	19.9	31.2	29.7	28.9
Phonographs	0.3	1.0	1.1	3.4	3.4	1.4	1.3	
Agricultural implements	12.6	10.5	11.3	5.5	5.6	3.8	3.7	
Engines and tractors				b	8.6	6.0	5.7	10.2
Windmills	0.5	0.4	0.4	0.2	0.2	0.1	0.1	
Steel barrels					0.3	0.4	0.4	0.5
Machine tools					4.8	4.2	4.0	4.8
Machine-tool accessories, n.e.c.[b]				b		d	2.6	3.1
Pumps	0.2	0.4	0.4	0.4	1.7	2.3	2.2	2.5
Textile machinery					2.6	2.0	1.9	1.9
Gas machines and meters	0.5	1.0	1.1	0.5	0.5	0.6	0.6	°
Refrigerators, nonmechanical	0.6	0.7	0.8	0.5	0.5	0.8	0.8	4.4
Refrigerators, mechanical						°	2.2	
Scales and balances	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.3
Sewing machines	2.6	2.1	2.2	1.1	1.1	0.8	0.6	0.7
Washing and ironing machines	0.4	0.4	0.4	0.6	0.6	1.0	0.9	0.7
TOTAL[f]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Basic data are given in Appendix C.
[b] N.e.c. denotes not elsewhere classified.
[c] Included in foundry and machine-shop products.
[e] Included in foundry and machine-shop products and electrical machinery.
[f] The columns do not add up to 100.0 in every instance be-